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# Learning Morse Code Characters: A Replication of the Keller Method

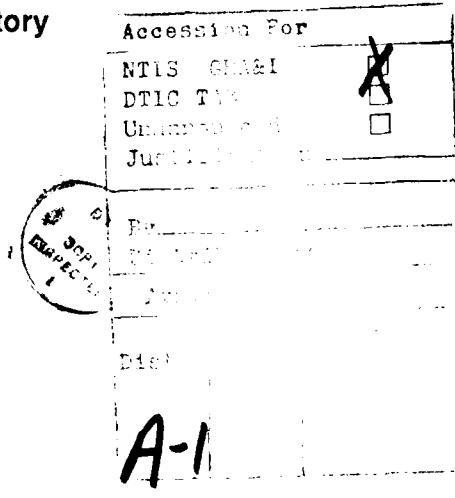
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The data analyses and figures for this report were done by Dr. Richard P. Kern. The formatting and final proofing were performed by Karen Bergquist.

This paper is dedicated to the memory of Dr. Douglas A. Ramsay (1932-1989), who died shortly after the experiments were completed.

LEARNING MORSE CODE CHARACTERS: A REPLICATION OF THE KELLER METHOD

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## LEARNING MORSE CODE CHARACTERS: A REPLICATION OF THE KELLER METHOD

### Introduction

The purpose of this study was twofold: perform a partial replication of a successful method of Morse code training developed for the armed services by Keller and his associates (Keller, 1943), and provide a group of subjects trained in Morse code for later use in studies on Morse code reception to be performed with the US Army Intelligence School, Fort Devens.

The Keller method of code training, called "code-voice", is based on procedures of paired associate learning, and on the use of feedback as reinforcement following responding (Keller, 1982). Training sessions are characterized by: (1) presentation of a code signal, (2) a short pause during which the student writes the corresponding character, and (3) identification of the correct character by the instructor. A hallmark of the code-voice method is the immediate reinforcement of the trainee's responses by the sounding of the correct character after its coded transmission. Additional reinforcement in the form of feedback is provided at the end of each run by permitting the trainee to immediately compare the current run's errors with previous run's. In the code-voice method there is no visual component or vocal drill as frequently used in other approaches to code training. The method is based upon the principle that immediate verbal confirmation of student responses, together with a decrease in the number of errors over successive runs, will provide sufficient motivation for students to efficiently learn the code.

### Method

#### Subjects

Nine individuals, 4 male and 5 female, ranging in age from 20 to 42, served as subjects during the summer and fall of 1989. These individuals were temporary employees of the US Army Research Institute, and participated on a strictly voluntary basis. None had received previous code training.

#### Procedure

At the beginning of the first training session, each subject was asked to read a set of instructions describing the training procedures, and was provided a sheet of paper containing the phonetic equivalent for each letter of the alphabet (see Appendixes A and B). Subjects were also given an opportunity to have questions answered. The first, and all subsequent sessions then proceeded as described below.

Subjects were provided data sheets to record their responses to the code characters. These sheets contained double rows of empty squares arranged so that each run of the 26 letters of the alphabet could be recorded in five letter groups (see Appendix C). Code characters for the 26 letters of the alphabet were presented in random order; no numbers were used. A run consisted of the 26 code characters for the letters of the alphabet randomly presented. Sessions were run daily, and lasted about fifty minutes during which twelve runs were completed.

Code was prerecorded on tape and transmitted to the subjects via headphones, one character at a time. Subjects were allowed up to three seconds in which to record their response in the upper row of boxes on the practice sheets. The correct letter was then announced on the tape. If they had correctly identified the letter, they would simply wait for the next code signal. If their response was incorrect, or if they had not written any letter in the top box, they now printed the correct letter in the lower box. A short pause followed, the next signal sounded, and the rest of the sequence occurred. This procedure was repeated until all 26 characters of the alphabet had been presented, completing the run. The subjects then took a short break during which they counted their errors by noting the entries in the lower row of boxes. The error score for the run was then written to the right of the row of boxes. Following this, the session proceeded with another run and continued until 12 runs had been completed.

During training sessions, every effort was made to closely approximate the training methodology employed in Keller's (1943) study, within present constraints. For this reason, students were encouraged to listen to the code signals in a unitary way rather than analyzing the signals into individual elements. In order to discourage the counting of dits and dahs, code signals were transmitted at a speed equivalent to 20 groups per minute. At this speed of transmission, each dit is 50 msec, each dah is 150 msec, and time between dits and dahs is 50 msec. In addition, training initial code acquisition at 20 groups per minute permits the sound patterns for each character to remain unchanged throughout subsequent speed building phases of training.

### Results

All subjects in this study successfully reached the mastery criterion of two successive errorless runs of the 26 coded alphabet signals. Table 1 shows the distribution of sessions required for mastery by the 9 subjects. The mean number of sessions required to complete the training was 12.8 sessions. While these findings do not agree with Keller's (1943) report of an average of 8.8

Table 1

Hours of Training to Master 26 Morse Code Characters

Hours to Master 26 Characters	Number of Students
1 - 4	0
5 - 8	0
9 - 12	5
13 - 16	2
17 - 20	2

hours using code-voice training, they are consistent with a second study (Keller and Taubman, 1943) in which an average of about 12 hours was required to reach mastery.

Of particular interest in the Keller and Taubman study was their focus on the difficulty level of characters during the initial learning phase. Using student records of errors and omissions, the relative difficulty of characters for each subject was compared with each other subject's relative difficulty of characters, and with all subjects in the Keller and Taubman study. Table 2 presents a correlation matrix (Pearson r) depicting these comparisons. Note the high level of agreement between the subjects in this study and Keller and Taubman's group, (1st column of coefficients). Also note the variability of difficulty level for characters among individual students (2nd through 10th rows of coefficients). The variability present among students was also consistent with Keller and Taubman's results.

Table 2

Correlation Matrix of Character Difficulty Level: Agreement of Ss with each other and with Keller and Taubman (1943)

	K&Ta	S1	S2	S3	S4	S5	S6	S7	S8	S9
K&T	1.00									
S1	.85	1.00								
S2	.81	.64	1.00							
S3	.75	.69	.86	1.00						
S4	.76	.70	.80	.77	1.00					
S5	.47	.40	.72	.66	.66	1.00				
S6	.77	.71	.65	.74	.77	.48	1.00			
S7	.65	.60	.82	.82	.75	.67	.56	1.00		
S8	.77	.65	.76	.62	.67	.46	.64	.60	1.00	
S9	.90	.79	.84	.76	.76	.47	.76	.72	.70	1.00

<sup>a</sup>Keller & Taubman (1943) data were converted from error scores to number correct to enable all correlations to be positive

Figure 1 depicts the percent of correctly identified characters as a function of number of sessions for each of the nine subjects used. Each panel presents 3 students, grouped in accordance with number of sessions required to reach mastery. The figure shows the individual differences occurring during the training, and reveals 3 different patterns to mastery: a swift and steady decline in error scores, fluctuation in error scores from session to session, and steady but slow progress to mastery level.

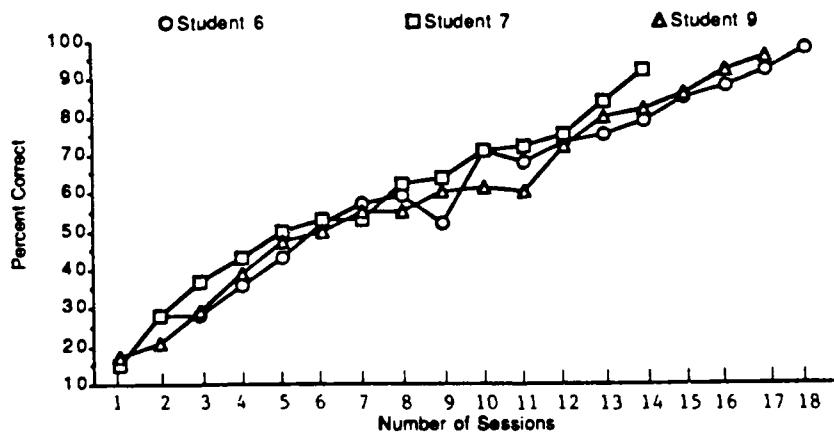
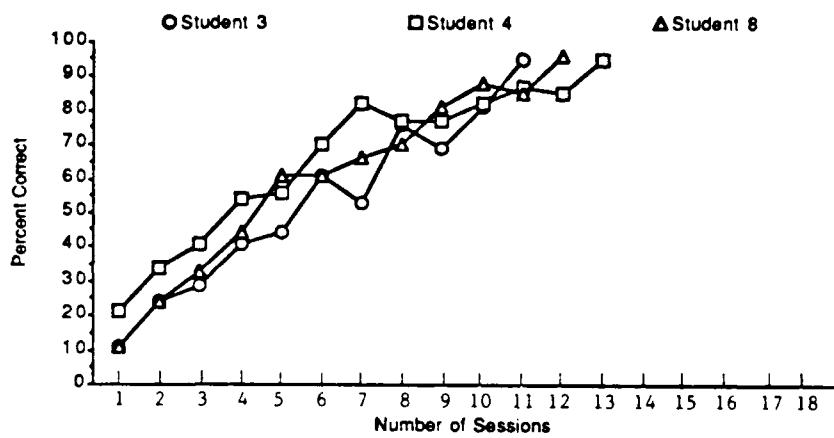
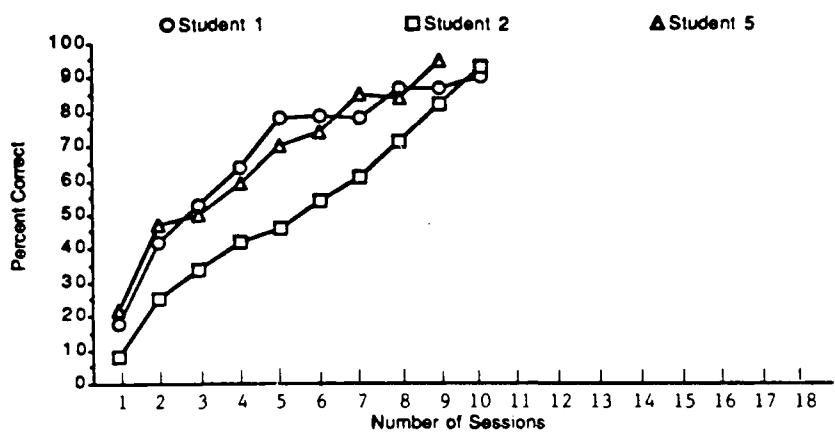


Figure 1. Morse code acquisition functions for each subject - grouped by similarity.

### Discussion

This study partially replicated Keller's method for initial Morse code character learning, and provided evidence that the code-voice method continues to be of value in Morse code training. Because the present study was a partial replication of Keller's 1943 study, caution should be observed when comparing results. For example, while Keller presented students with 100 signals in each run with four runs occurring in each session, 26 signals per run with 12 runs per session were presented in this study. Thus students in Keller's study received a total of 400 signals per session with a pause and error summation opportunity four times during the session, while students in the present study were given 312 characters with a pause and error summation opportunity 12 times per session. Furthermore, the criterion for completion was different for the two studies. For Keller's study, students were required to achieve three consecutive runs of 100 characters with 95% accuracy, while in this study students reached mastery level when they achieved two consecutive runs of 26 characters with 100% accuracy. In addition, Keller used 26 letters of the alphabet and digits 0 through 9, while only the 26 letters were used in this study. Both studies had equal representation of the signals during the course of training since signals were presented in random order for each run. Given that Keller used a stricter mastery criterion, and that he required students to learn 36 characters, it is not clear why Keller obtained faster learning. However, it is clear that relatively small modifications to this method can have substantial effects on acquisition.

The Intelligence School at Fort Devens currently uses a combination of methods in their training program. The intercept training program employs some elements of Keller's method in combination with an analytical approach. For example, Fort Devens employs such analytical procedures as voice and finger drills, and a visual learning component during early stages of code training. During the character learning phase, students are provided with correct response feedback for each character, but it is in the form of a lighted key on the visual display of the keyboard rather than a "voice" saying the phonetic name for the correct character. The lighted key goes out once the trainee enters the correct keystroke and, as a result, this type of feedback does not provide an on-going record of progress in the way that Keller's practice sheets do.

Keller based the code-voice training method on psychological principles relating to regular, immediate reinforcement of a subject's response to a discriminative stimulus. Consistent with Keller's work, the subjects in this study were provided with feedback after each character and at each step in the procedure. This seemed to be effective since all of the students successfully reached the criterion of two consecutive perfect runs. Many questions remain, however, about the exclusive use of this method in other phases of Morse code training, particularly the speed-building phase. For that reason, caution should be exercised when drawing conclusions for large-scale training programs in the complex and demanding task area of Morse code training. Code training procedures are currently being examined within the Army, and research is being conducted to try to find improved training techniques. Through this work and further research, facilitative strategies which will increase the effectiveness of Morse code training may be found.

References

Keller, F.S. (1943). Studies in international Morse code I. A new method of teaching code reception. Journal of Applied Psychology, 27, 407-415.

Keller, F. S. (1982). Pedagogue's progress. Lawrence, Kansas: TRI Publications.

Keller, F. S. & Taubman, R. E. (1943). Studies in international Morse code 2. Errors made in code reception. Journal of Applied Psychology, 27, 504-509.

## APPENDIX A

### INSTRUCTIONS

Morse code signals are made up of combinations of short and long tones. During this training you will only receive signals which make up the English alphabet. Each letter will be sent individually over the earphones and you will be given enough time to write your guess as to the correct letter. Because each letter is sent at a "normal" transmitting speed, it is best that you try not to analyze the tones making up a letter. Rather, try to hear the code signals as unitary and not as a combination of elements.

This is the type of record blank you will use throughout your training. It is made up of double rows of small squares broken down into blocks of ten. The manner of filling in the squares is very simple. In each practice session, you will hear a succession of 26 code signals, one for each letter of the alphabet but presented in random order. To each of these signals you will try to respond by printing the appropriate letter in one of the squares in the upper row within each block, working from left to right across the page.

The signals will be presented one at a time, and you will be given about three seconds in which to respond to each of them; then the tape will announce the letter you should have printed in the upper row during the three-second period. The announcement will let you know whether you were right or wrong in responding to the signal as you did.

If you were right there is nothing to be done but prepare yourself for the next signal and to put your response in the next square to the right. If your guess was wrong, print the correct response in the square below your incorrect response. If the announcement is made before you make a response in the upper square, leave it blank and copy the correct response in the lower square.

Following a short pause, the next signal will be sounded and you will attempt to identify it just as you did before and after three seconds the tape will announce the correct letter. This will be repeated until all 26 characters of the alphabet are presented. There will be a short break following each block of five letters and a longer break between each run of the alphabet.

Let us follow an example of using the answer sheet.

O	A	S	V
S	C	D	X

H	B	N
L	J	G

Suppose that, in a practice run, the first signal sent was an 'S', but you mistook it for an 'O' and responded as shown in the first upper square of the sample form. When you heard the tape announce 'Sierra,' you should have printed an 'S' directly below the one containing your incorrect 'O.' To the next signal let us suppose that you responded with an 'A,' which was confirmed at the end of the usual three seconds with the tape announcing 'Alpha.' Since it was correct, you needn't make any correction in the lower square. To the third signal, you were unable to make any response within the three-second period and the tape announced the correct response as 'Charlie.' As in the case of the 'S,' you would then have placed a 'C' in the square immediately beneath the one which you failed to fill in before the announcement.

In this manner you would have proceeded throughout the entire 26-signal run, using the lower squares only in the case of an incorrect or omitted response. At the end of a run you will be able to add up your errors quickly by totalling the number of entries in the lower squares of each row. Blank squares in the lower row mean, of course, correct responses.

At first you will probably make a great many errors. That is, you will fail to respond correctly to some signals, and you will not be able to respond at all to others within the allotted time. With the answer sheet in front of you, however, you'll immediately be able to notice the improvement as you gradually learn the signals.

APPENDIX B  
CODE CHARACTER NAMES

<u>CHARACTER</u>	<u>PHONETIC</u>
A	ALFA
B	BRAVO
C	CHARLIE
D	DELTA
E	ECHO
F	FOXTROT
G	GOLF
H	HOTEL
I	INDIA
J	JULIETT
K	KILO
L	LIMA
M	MIKE
N	NOVEMBER
O	OSCAR
P	PAPA
Q	QUEBEC
R	ROMEO
S	SIERRA
T	TANGO
U	UNIFORM
V	VICTOR
W	WHISKEY
X	XRAY
Y	YANKEE
Z	ZULU

APPENDIX C

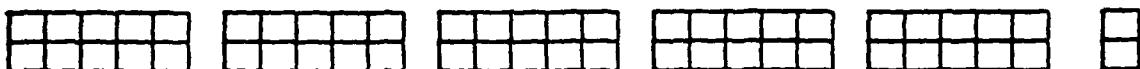
MORSE CODE PRACTICE SHEET

NAME..... DATE..... TIME.....

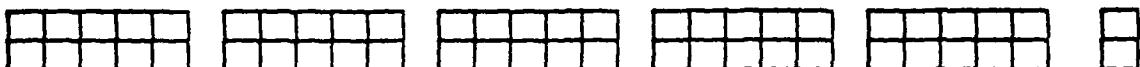
SESSION NO..... TRAINING... TEST... (NO FEEDBACK)

PAGE    OF   

CODE SEQUENCE #.....



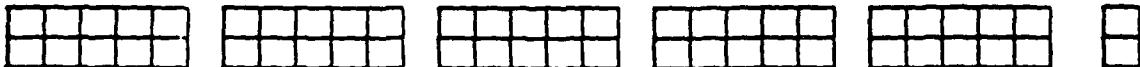
CODE SEQUENCE #.....



CODE SEQUENCE #.....



CODE SEQUENCE #.....



CODE SEQUENCE #.....



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